

Record of Decision for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel

AGENCY: Department of Energy (DOE)

ACTION: Record of Decision (ROD)

SUMMARY: DOE has issued a *Final Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel* (final EIS) (*Notice of Availability*, 65 FR 47987, August 4, 2000) (DOE/EIS-0306, July 2000). After careful consideration of public comments on the draft EIS and programmatic, environmental, nonproliferation, and cost issues, DOE has decided to implement the preferred alternative identified in the final EIS. That is, DOE has decided to electrometallurgically treat the Experimental Breeder Reactor-II (EBR-II) spent nuclear fuel (about 25 metric tons of heavy metal) and miscellaneous small lots of sodium-bonded spent nuclear fuel. The fuel will be treated at Argonne National Laboratory-West (ANL-W). Because of the different physical characteristics of the Fermi-1 sodium-bonded blanket spent nuclear fuel (about 34 metric tons of heavy metal), DOE has decided to continue to store this material while alternative treatments are evaluated. Should no alternative prove more cost effective for this spent nuclear fuel, electrometallurgical treatment (EMT) of the Fermi-1 spent nuclear fuel remains a key option.

ADDRESSES:

The final EIS and this ROD are available on the Office of Environment, Safety and Health National Environmental Policy Act (NEPA) home page at <http://www.tis.eh.doe.gov/nepa/> or on the Office of Nuclear Energy, Science and Technology home page at <http://nuclear.gov>.

You may request copies of the final EIS and this ROD by calling the toll-free number 1-877-450-6904, by faxing requests to 1-877-621-8288, via electronic mail to sodium.fuel.eis@hq.doe.gov, or via mail to: Susan Lesica, Document Manager, Office of Nuclear Energy, Science and Technology, NE-40, U.S. Department of Energy, 19901 Germantown Road, Germantown, Maryland 20874.

FOR FURTHER INFORMATION: For information on the alternative strategies for the treatment and management of sodium-bonded spent nuclear fuel, contact Susan Lesica at the address listed above. For general information on the DOE NEPA process, please contact: Carol Borgstrom, Director, Office of NEPA Policy and Compliance (EH-42), U.S. Department of Energy, 1000 Independence Avenue, S.W., Washington, D.C. 20585, (202) 586-4600, or leave a message at 1-800-472-2756.

SUPPLEMENTARY INFORMATION:

I. Background

For nearly four decades, research, development, and demonstration activities associated with liquid metal fast breeder reactors were conducted at EBR-II, about 40 miles west of Idaho Falls, Idaho; the Enrico Fermi Atomic Power Plant (Fermi-1) in Monroe, Michigan; and the Fast Flux Test Facility at the Hanford Site in Richland, Washington. These activities generated approximately 60 metric tons of heavy metal of sodium-bonded spent nuclear fuel for which DOE is now responsible for safe management and disposition.

Sodium-bonded spent nuclear fuel is distinguished from other nuclear reactor spent nuclear fuel by the presence of metallic sodium (a highly reactive material), metallic uranium and plutonium (which are also potentially reactive), and in some cases, highly enriched uranium. Metallic sodium in particular presents challenges for management and ultimate disposal of this spent nuclear fuel. Metallic sodium reacts with water to produce explosive hydrogen gas and corrosive sodium hydroxide that would likely not be acceptable for geologic disposal.

DOE's sodium-bonded spent nuclear fuel is of two general types: driver fuel and blanket fuel. Driver fuel is used mainly in the center of the reactor core to "drive" and sustain the fission chain reaction. Blanket fuel is usually placed at the outer perimeter of the core and is used to breed plutonium-239, a fissile material, and for shielding. The blanket and driver fuel addressed in this ROD contain metallic sodium between the cladding (outer layer) and the metallic fuel pins to improve heat transfer from the fuel to the reactor coolant through the cladding. When the driver fuel is irradiated for some period of time, the metallic fuel swells as fission products are generated until it reaches the cladding wall. During this process, metallic sodium enters the metallic fuel and becomes inseparable from it. In addition, fuel and cladding components interdiffuse to such an extent that mechanical stripping of the driver spent nuclear fuel cladding is not a practical means of removing the sodium. On the other hand, when blanket fuel is irradiated, the metallic fuel does not swell to the same degree as the driver fuel because less fission occurs, producing fewer fission products (i.e., lower "burnup"). As a result, minimal metallic sodium enters the fuel and there is no interdiffusion between the fuel and cladding. This

allows mechanical stripping of the blanket spent nuclear fuel cladding. Because of these differences between irradiated driver fuel and blanket fuel, there are different treatment alternatives for each fuel type.

There are approximately 60 metric tons of heavy metal in the DOE's inventory of sodium-bonded spent nuclear fuel. The inventory includes 25 metric tons of heavy metal of fuel from EBR-II, of which three metric tons of heavy metal are driver fuel and 22 metric tons of heavy metal are blanket fuel. EBR-II fuel is stainless steel clad and is stored at the Idaho National Engineering and Environmental Laboratory (INEEL). The EBR-II driver fuel contains highly enriched uranium in a uranium alloy, typically either zirconium or fissium (an alloy of molybdenum, ruthenium, rhodium, palladium, zirconium, and niobium). The EBR-II blanket fuel contains depleted uranium in metallic form. Approximately 34 metric tons of heavy metal are blanket fuel from the Fermi-1 reactor and are stored at INEEL. This blanket fuel consists of stainless steel-clad, depleted uranium in a uranium-molybdenum alloy. Fermi-1 blanket elements are similar to EBR-II blanket elements in enrichment but differ in dimensions (Fermi-1 elements are larger), form (Fermi-1's uranium-molybdenum alloy versus EBR-II's uranium metal), and burnup. Because of its lower burnup, the Fermi-1 blanket fuel, which contains only about 0.2 percent plutonium by weight compared to approximately 1 percent plutonium by weight for the EBR-II blanket fuel, is subject to less stringent safeguard and security requirements than the EBR-II blanket fuel. This is an important consideration in the cost of storing these two fuel types.

The remainder of the DOE's sodium-bonded spent nuclear fuel inventory consists of small lots of miscellaneous sodium-bonded fuel, with a combined weight of approximately 400 kilograms of heavy metal (or 0.4 metric tons of heavy metal). Three hundred kilograms of this miscellaneous fuel are from liquid metal reactor test assemblies containing driver fuel that were irradiated at the Fast Flux Test Facility. The remaining 100 kilograms of heavy metal are small quantities of fuel from liquid metal reactor experiments that have metallic sodium or an alloy of sodium and potassium. These fuels differ in cladding composition, uranium content, enrichment, and burnup. Some of the fuel consists of uranium and/or plutonium carbides, nitrides, and oxides in addition to metal uranium or uranium alloy. This fuel is stored at several DOE sites, including the Hanford Site, Oak Ridge National Laboratory, Savannah River Site (SRS), Sandia National Laboratories, and INEEL. Those lots stored outside INEEL will be transported to INEEL pursuant to the Record of Decision (60 FR 28680, June 1, 1995) for the Programmatic Spent Nuclear Fuel EIS (DOE/EIS-0203, April 1995).

Before electrometallurgical treatment could be considered as a technology choice for treating EBR-II spent nuclear fuel, an appropriate demonstration project was needed to evaluate its technical feasibility. As a preliminary step to demonstration, DOE requested that the National Research Council conduct an independent assessment of electrometallurgical treatment technology and its potential application to EBR-II spent nuclear fuel. In its report, published in 1995, the National Research Council recommended that DOE proceed with demonstrating the technical feasibility of electrometallurgical treatment using a fraction of the EBR-II spent nuclear

fuel. DOE then conducted an environmental assessment of the demonstration project. The environmental assessment was completed in May 1996 and resulted in a Finding of No Significant Impact. In June 1996, DOE initiated a three-year testing program at ANL-W to demonstrate the technical feasibility of electrometallurgical treatment of up to 100 EBR-II driver spent nuclear fuel assemblies and up to 25 EBR-II blanket spent nuclear fuel assemblies. The two types of EBR-II spent nuclear fuel, driver and blanket, are typical of most of DOE's sodium-bonded spent nuclear fuel.

Working with DOE and the National Research Council review committee, ANL-W established four criteria for evaluating the demonstration. Upon completion of the demonstration, all key performance criteria were met or exceeded, proving the technical feasibility of using electrometallurgical treatment technology to treat sodium-bonded spent nuclear fuel. In addition, the demonstration project validated the throughput rate of the sodium-bonded spent nuclear fuel, quantified all process streams, fine-tuned the operational parameters, refined the electrometallurgical treatment equipment, and provided actual waste forms for characterization.

DOE is now at the point of deciding how to manage the sodium-bonded spent nuclear fuel to facilitate its ultimate disposal in a geologic repository. The reasonable alternatives for this proposed action are predicated on the technology options available to DOE. There is some risk in implementing any alternative in that the resultant waste form may still not be acceptable for disposal in a geologic disposal. DOE currently is studying Yucca Mountain in Nevada as a

potential site for development of a geologic repository. Under current schedules, final waste acceptance criteria would not be available until about 2005, and then only if a decision has been made to proceed with development of a repository at Yucca Mountain and the Nuclear Regulatory Commission issues a licence to construct the repository. The preliminary waste acceptance criteria for Yucca Mountain are used as a basis for planning treatment of the sodium-bonded spent nuclear fuel.

Currently, more than 98 percent of DOE's sodium-bonded spent nuclear fuel is located at INEEL, near Idaho Falls, Idaho. DOE committed to remove all spent nuclear fuel from Idaho by 2035 in a 1995 agreement with the State of Idaho (Settlement Agreement and Consent Order issued on October 17, 1995, in the actions of *Public Service Co. of Colorado v. Batt*, No. CV 91-0035-S-EJL [D. Id.], and *United States v. Batt*, No. CV 91-0054-EJL [D. Id.]). Before sodium-bonded spent nuclear fuel can be removed from the State of Idaho for ultimate disposal, some or all of the fuel may require treatment.

Purpose and Need for Agency Action

Sodium-bonded spent nuclear fuel contains metallic sodium that was used as a heat-transfer medium within the stainless steel cladding (outer layer) of the nuclear fuel. While sodium has been removed from the fuel's external surface, some sodium remains bonded to the uranium metal alloy fuel within the cladding and cannot be removed without further treatment. This sodium could complicate compliance with the eventual final repository waste acceptance

criteria. Metallic sodium reacts vigorously with water, producing heat, potentially explosive hydrogen gas, and sodium hydroxide, a corrosive substance. Sodium is also pyrophoric (i.e., susceptible to spontaneous ignition and continuous combustion). Most (i.e., 99 percent by weight) of the sodium-bonded spent nuclear fuel contains metallic uranium and plutonium. These metals are reactive in the presence of air and moisture. The Yucca Mountain preliminary waste acceptance criteria exclude reactive and potentially explosive materials beyond trace quantities. Additionally, some of the sodium-bonded spent nuclear fuel contains highly enriched uranium that could create criticality (that is, a self-sustained nuclear chain reaction) concerns requiring control methods.

To ensure that the terms of the State of Idaho Settlement Agreement and Consent Order are met and to facilitate disposal, DOE needs to reduce the uncertainties associated with qualifying sodium-bonded spent nuclear fuel for disposal. Treating the sodium-bonded spent nuclear fuel could make it significantly easier to dispose of the fuel. In addition, DOE could significantly reduce the safeguard and security costs associated with long-term storage of the EBR-II blanket spent nuclear fuel, due to its high plutonium content, by treating the fuel. Furthermore, delaying the implementation of this decision could result in a loss of capability and of technical staff knowledgeable about and experienced with the demonstration project. This was an important consideration in the decision to proceed with this NEPA review.

NEPA Process

On February 22, 1999, DOE published in the *Federal Register* a Notice of Intent to prepare an *Environmental Impact Statement for Electrometallurgical Treatment of Sodium-Bonded Spent Nuclear Fuel in the Fuel Conditioning Facility at Argonne National Laboratory-West* (64 FR 8553). During the 45-day scoping period, DOE received 228 comments on the proposed scope of the EIS via mail, telephone, facsimile, and during the four public scoping meetings. DOE considered these comments and, as a result, changed the proposed action of the EIS as well as the structure of the alternatives. The proposed action was changed from electrometallurgical treatment of sodium-bonded spent nuclear fuel at the Fuel Conditioning Facility at ANL-W to the treatment and management of sodium-bonded spent nuclear fuel. This change was made to address concerns about bias for one treatment technology over others. The alternatives were restructured to reflect differences in the characteristics of the sodium-bonded spent nuclear fuel types. Thus, several alternatives were added that treat blanket and driver spent nuclear fuel by different technologies.

In July 1999, DOE published the *Draft Environmental Impact Statement for the Treatment of Sodium-Bonded Spent Nuclear Fuel*. The 45-day comment period began on July 31, 1999, and was scheduled to end on September 13, 1999. In response to commentor requests, the comment period was extended an additional 15 days through September 28, 1999. Four public hearings were held during the comment period. A total of 494 comments were received and considered, and responses can be found in the final EIS, which was issued in July 2000. Most of these comments focused on the following issues: (1) the purpose, need for, and timing

of the proposed action; (2) new waste forms produced by the proposed action, their acceptability in a geologic repository, and the disposition of uranium and plutonium by-products; (3) the public availability of information considered relevant to reviewing the draft EIS; (4) the cost of the various alternatives; (5) the impacts of the proposed action on U.S. nuclear nonproliferation policy; (6) technical or NEPA-related issues regarding technologies and alternatives; and (7) issues related to the affected environment and the environmental consequences. Volume 2, Section A.2 of Appendix A of the final EIS provides an overview of the public hearings and DOE's responses to all comments. No comments have been received on the final EIS.

II. Treatment Technology Options

EMT Process

The EMT process uses electrorefining, an industrial technology used to produce pure metals from impure metal feedstock. Electrorefining has been used to purify metal for more than 100 years. The electrometallurgical process for treatment of EBR-II blanket and driver spent nuclear fuel assemblies containing metallic fuel was developed at Argonne National Laboratory. The process has been demonstrated for the stainless steel clad uranium alloy fuel used in EBR-II. Modifications to the process could be used for the treatment of oxide, nitride, and carbide sodium-bonded spent nuclear fuel. The fuel would be chopped, placed in molten salt, and electrorefined. After electrorefining, the molten salt, fission products, sodium, and transuranics, including plutonium, would be removed from the electrofiner, mixed with a filter and ion-exchange agent known as zeolite, and heated so the salt becomes sorbed into the zeolite

structure. Glass powder then would be added to the zeolite mixture and consolidated to produce a ceramic high-level radioactive waste form. The uranium would be removed, melted (and depleted uranium would be added, if necessary), and processed in a metal casting furnace to produce low-enriched or depleted uranium ingots. The ingots would be stored until a disposition decision is made through a separate NEPA review. The stainless steel cladding hulls and the insoluble fission products would be melted in the casting furnace to produce a metallic high-level radioactive waste form.

Plutonium Uranium Extraction (PUREX) Process

The PUREX process has been used extensively throughout the world since 1954 to separate and purify uranium and plutonium from fission products contained in spent nuclear fuel and irradiated uranium targets. It is a chemical separation process that uses aqueous solvent extraction to perform the separation. DOE has two operating facilities at the SRS, F-Canyon and H-Canyon, that use the PUREX process. Use of these facilities for treating sodium-bonded spent nuclear fuel involves certain restrictions inherent in the design: (1) the sodium complicates the process as employed in the SRS facilities; (2) the stainless steel cladding would require significant modifications or additions to the existing facilities; and (3) the presence of alloys (e.g., zirconium) is incompatible with the SRS dissolution process. For this reason, treatment of driver sodium-bonded spent nuclear fuel is not feasible without significant modification to the existing PUREX process. However, the F-Canyon facility could be used without modifications for the blanket sodium-bonded spent nuclear fuel if the spent nuclear fuel were de-clad and the sodium were removed prior to the process.

After processing, the following would be produced: (1) an aqueous high-level radioactive waste containing the bulk of the fission products, americium, and neptunium; (2) a material stream containing the recovered plutonium (as plutonium metal); and (3) a material stream containing the recovered uranium (as uranium oxide). The aqueous high-level radioactive waste would be processed to a borosilicate glass form. The uranium oxide would be stored on site as depleted uranium. The plutonium would be disposed of in accordance with the ROD (65 FR 1608, January 11, 2000) for the *Surplus Plutonium Disposition Final Environmental Impact Statement* (DOE/EIS-0283, November 1999).

High-Integrity Can Packaging

High-integrity can packaging would provide substitute cladding for damaged or declad fuel and another level of containment for intact fuel. The can is constructed of a highly corrosion-resistant material to provide corrosion protection during storage. The high-integrity cans are placed into standardized canisters that are ready for disposal in waste packages. High-integrity cans would be used to store the sodium-bonded spent nuclear fuel on site until it can be shipped to a repository.

The EIS analysis for packaging sodium-bonded spent nuclear fuel in high-integrity cans was performed with and without decladding and/or sodium removal. Packaging sodium-bonded blanket spent nuclear fuel in high-integrity cans with sodium removal was analyzed in the EIS under Alternative 2. Packaging sodium-bonded spent nuclear fuel in high-integrity cans without sodium removal was considered in the EIS as a direct disposal option under the No Action

Alternative. The high-integrity cans would be placed in dry storage at ANL-W. They would be placed into a standardized canister for transportation and eventual placement in waste packages in a geologic repository.

Melt and Dilute Process

The melt and dilute process involves chopping and melting the spent nuclear fuel and diluting it by adding depleted uranium or other metals. There are three options for the melt and dilute process that are applicable to sodium-bonded spent nuclear fuel. In the first option, bare uranium blanket spent nuclear fuel pins with the sodium removed would be melted with aluminum at SRS using technology similar to the technology that DOE selected in the ROD (65 FR 48224, August 7, 2000) for the treatment of aluminum-clad research reactor fuel at SRS. The second and third options would be conducted at ANL-W using metallurgical technology developed for uranium and stainless steel cladding. In the second option, blanket spent nuclear fuel elements would be melted with the cladding and additional stainless steel. In the first two options, dilution of the fissile component of the uranium would not be needed because it is present in amounts far less than in natural uranium. The third option would involve developing a new melt and dilute process capable of handling sodium volatilized from processing the chopped driver spent nuclear fuel elements with the sodium and cladding intact. In this process option, the fuel and stainless steel would be melted under a layer of material such as molten salt to oxidize the molten sodium. The process can be used for the metallic sodium-bonded spent nuclear fuel. The non-metallic uranium nitride, oxide, and carbide sodium-bonded spent nuclear fuel cannot be treated with this process because of their high melting points.

III. Alternatives

The following alternatives were analyzed in the EIS.

Alternative 1 - Both driver and blanket fuel would be treated using EMT at ANL-W.

Alternative 2 - EMT would be used at ANL-W to treat the driver fuel. The sodium from the blanket fuel would be removed without decladding, and the blanket elements would be packaged in high-integrity cans. Sodium removal and packaging would occur at ANL-W.

Alternative 3 - EMT would be used at ANL-W to treat the driver fuel. The fuel pins in the blanket fuel would be separated from the cladding and cleaned to remove metallic sodium at ANL-W. The cleaned fuel pins would be shipped to SRS for treatment using the PUREX process at the F-Canyon facility.

Alternative 4 - EMT would be used at ANL-W to treat the driver fuel. The metallic sodium would be removed from the blanket fuel without decladding. Then the elements would be treated using the melt and dilute process. All treatment would occur at ANL-W.

Alternative 5 - EMT would be used at ANL-W to treat the driver fuel. The fuel pins in the blanket fuel would be separated from the cladding and cleaned to remove the metallic sodium at ANL-W. Then they would be shipped to SRS and treated using the melt and dilute process.

Alternative 6 - Both the driver and blanket fuel would be treated at ANL-W using the melt and dilute process, which would be modified slightly for each fuel type.

No Action Alternative

Under the No Action Alternative, all or part of the sodium-bonded spent nuclear fuel would not be treated (no sodium would be removed), except for stabilization activities that may be

necessary to prevent potential degradation of some of the spent nuclear fuel. Two options were analyzed: (1) the sodium-bonded spent nuclear fuel would continue to be stored until 2035 at its current location, subject only to activities dictated by the amended ROD (61 FR 9441, March 1996) for the Programmatic Spent Nuclear Fuel EIS and other existing site-specific NEPA documentation or until another technology, currently dismissed as an unreasonable alternative because it is less mature (e.g., Glass Material Oxidation and Dissolution System (GMODS) or plasma arc), is developed; and (2) the sodium-bonded spent nuclear fuel would be disposed of directly in a geologic repository without treatment. The fuel would be packaged in high-integrity cans without sodium removal. Option 2 would not meet current DOE or Nuclear Regulatory Commission (10 CFR 60.135) repository acceptance criteria.

Preferred Alternative

In the final EIS, DOE identified electrometallurgical treatment as its preferred alternative for the treatment and management of all sodium-bonded spent nuclear fuel, except for the Fermi-1 blanket fuel. The No Action Alternative is preferred for the Fermi-1 blanket spent nuclear fuel. Thus, the preferred alternative is a combination of Alternative 1 and the No Action Alternative.

IV. Alternatives Considered but Dismissed

In identifying the reasonable alternatives for evaluation in the EIS, two separate issues led to the determination of alternatives that were considered and dismissed: (1) the level of maturity of the alternative technologies and (2) the level of effort required to modify an existing facility to implement a specific technology. The construction of new facilities when existing facilities are

still operational was not considered a reasonable option because of cost implications. The GMODS process and the direct plasma arc-vitreous ceramic process are not as mature as the electrometallurgical, melt and dilute, and PUREX processes when applied to sodium-bonded spent nuclear fuel. The GMODS and plasma arc processes both require extensive research and development before they can be proven successfully to treat sodium-bonded spent nuclear fuel. The GMODS and plasma arc-vitreous ceramic processes each present specific technological challenges that cannot be answered without demonstration in pilot-scale plants. In comparison, the melt and dilute process is being tested and evaluated and has been selected for treatment of aluminum-clad spent nuclear fuel at SRS. However, use of the melt and dilute process for sodium-bonded driver spent nuclear fuel would require some technology enhancements. In addition, unlike the other technologies that would not require new construction, both of these technologies (i.e., GMODS and plasma arc) would require the installation of large, specialized equipment in new hot cell facilities, the size and complexity of which are not determined sufficiently to allow detailed environmental impact analysis.

V. Summary of Environmental Impacts

This section summarizes the environmental impacts associated with the No Action Alternative and the six alternatives under the proposed action that were evaluated in the EIS. For the No Action Alternative and the six alternatives evaluated, the necessary facilities already exist.

Except for internal building modifications and new equipment installation, no construction activities would be required. Therefore, the proposed action would have little or no impact on land resources, visual resources, noise, geology and soils, ecological resources, and cultural and

paleontological resources.

For the alternatives evaluated, the analyses showed that there would be no significant impacts on air quality, water resources, socioeconomics, public and occupational health and safety, environmental justice, and transportation. The radiological and nonradiological gas and liquid releases, as well as the associated exposures to workers and the public, would be well within regulatory standards and guidelines.

A fundamental assumption made under the No Action Alternative is that the sodium-bonded spent nuclear fuel will eventually be disposed of in a manner similar to the rest of the spent nuclear fuel owned by DOE and within the time period over which institutional controls could reliably be assumed to be in effect. If the sodium-bonded spent nuclear fuel has not been disposed of before 2035, the temporarily stored fuel would be removed from the State of Idaho by the year 2035. Should such removal be necessary, the potential environmental impacts would be evaluated in a separate NEPA review. The continued storage of sodium-bonded spent nuclear fuel in the State of Idaho or elsewhere, beyond time periods for which institutional controls could reliably be assumed to be effective, could lead to significant impacts to the environment and the health and safety of the public from radioactive releases caused by the gradual degradation of the fuel and its containment.

VI. Environmentally Preferred Alternative

As discussed in the previous section, the environmental impact analysis indicates that none of the action alternatives would result in significant environmental impacts. Further, small

differences in potential environmental impacts among the alternatives do not provide a strong basis to discriminate among them. The following discusses some of the small differences.

Transportation: Alternatives involving treatment at ANL-W would avoid the need to transport spent nuclear fuel to SRS, notwithstanding that the analysis shows that the risks associated with such transportation are small.

Waste and Material Streams: The alternatives differ with respect to the quantities and types of waste streams and material that would be produced. The EIS presents a comparison of the volumes of high-level radioactive, low-level radioactive, and transuranic waste for each alternative (e.g., see Table S-4 on Page S-44).

- High-Level Waste. All of the alternatives would result in some form of spent nuclear fuel or high-level waste requiring storage and disposal. PUREX processing would generate liquid high-level waste that would require storage and eventual treatment by vitrification into glass canisters at the SRS. DOE regards the alternative using this technology option as less environmentally preferred than the other action alternatives, primarily because it is the only alternative that would generate liquid high-level waste. On the other hand, the volume of glass high-level waste ultimately produced that would require disposal in a geologic repository would be smaller than the volume of spent nuclear fuel and high level waste under any of the other alternatives. Also, this waste form has been tested and analyzed extensively under potential repository conditions.

Electrometallurgical treatment would produce two new high-level waste forms (i.e., metallic and ceramic), and the melt and dilute process also would produce a new metallic form (i.e., a melt and dilute product). DOE expects that these waste forms and high-integrity cans that do not contain metallic sodium would be suitable for disposal in a geologic repository.

- Low-Level and Transuranic Waste. With the exception of Alternative 2, all of the action alternatives would generate greater volumes of low-level and transuranic waste than the No Action Alternative. Existing waste management infrastructure is adequate to safely manage these wastes under all of the alternatives, and the EIS shows that the associated environmental impacts would be small.
- Other Material Streams. Two of the treatment technology options would generate other material streams requiring storage and disposition. Electrometallurgical treatment would produce low-enriched and depleted uranium ingots, which would be stored safely pending decisions on their ultimate disposition. PUREX processing would generate uranium oxide and plutonium metal. The uranium oxide would be stored at SRS as depleted uranium, and the plutonium would be subject to the Record of Decision for the *Surplus Plutonium Disposition Final Environmental Impact Statement*.

Long-Term Uncertainties: The No Action Alternative would result in the least environmental impacts in the short-term. However, under the No Action Alternative metallic sodium would not be removed or converted to a non-reactive form and would pose long-term risks. Further,

if treatment were required in the future to remove or deactivate the sodium, the associated environmental impacts would be incurred then. In contrast, all of the action alternatives would either remove or convert the metallic sodium into a non-reactive form, which would reduce the risks associated with long-term storage and uncertainties regarding disposal.

VII. Other Considerations

In addition to environmental issues, DOE considered other issues in determining the treatment and disposition path of sodium-bonded spent nuclear fuel. Among these are cost, nuclear proliferation concerns, and the National Research Council's independent review of electrometallurgical techniques, including the research and demonstration project.

DOE's Cost Study of Alternatives Presented in the Draft Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel showed that the lowest cost alternative was the direct disposal option under the No Action alternative. However, untreated sodium-bonded spent nuclear fuel does not meet current DOE or Nuclear Regulatory Commission repository acceptance criteria requirements. The cost study also concluded that the cost of alternatives 1, 2, and 3 are similar and difficult to distinguish from each other, as are the costs of alternatives 4, 5, and 6. This is due to an incomplete understanding of the technical requirements for the treatment technology, uncertainty in the repository waste acceptance criteria, and unquantifiable programmatic risks associated with some of the alternatives.

After reviewing the various alternatives, DOE's Office of Arms Control and Nonproliferation concluded that "All but one alternative--the one involving plutonium-uranium extraction reprocessing at the SRS--are fully consistent with U.S. policy with respect to reprocessing and nonproliferation." (DOE/Office of Arms Control and Nonproliferation, *Nonproliferation Impacts Assessment for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel*, July 1999)

The National Research Council's final report on *Electrometallurgical Techniques for DOE Spent Fuel Treatment* (April 2000) concluded that "The EBR-II demonstration project has shown that the electrometallurgical technique can be used to treat sodium-bonded spent nuclear fuel." The report further stated that "the committee has found no significant technical barriers in the use of electrometallurgical technology to treat EBR-II spent fuel, and EMT therefore represents a potentially viable technology for DOE spent nuclear fuel treatment."

VIII. Decision

DOE has decided to implement the preferred alternative as stated in the final EIS. That is, DOE will electrometallurgically treat the EBR-II spent nuclear fuel (about 25 metric tons of heavy metal) and miscellaneous small lots of sodium-bonded spent nuclear fuel. The fuel will be treated at ANL-W. In addition, Fermi-1 sodium-bonded spent nuclear fuel (about 35 metric tons of heavy metal) will be stored while alternative treatments are evaluated further. Should no alternative prove more cost-effective for this spent nuclear fuel, electrometallurgical treatment of the Fermi-1 spent nuclear fuel remains a key option.

DOE will validate the cost of using alternative treatment techniques (e.g., sodium removal and placement in high-integrity cans) for the Fermi-1 blanket spent nuclear fuel. These techniques may be economically favorable for the Fermi-1 blanket spent nuclear fuel because of characteristics that distinguish it from the EBR-II spent nuclear fuel. The most significant distinguishing characteristic is that the Fermi-1 blanket spent nuclear fuel does not require the extensive safeguards and security measures that are required for the EBR-II blanket fuel. The difference in security requirements for these two types of fuel is a result of the difference in plutonium content; the EBR-II blanket fuel has 30 times more plutonium at a greater concentration than the Fermi-1 blanket fuel. DOE will proceed with the electrometallurgical treatment of the EBR-II spent nuclear fuel and monitor the results and costs while continuing the evaluation of sodium removal techniques for the Fermi-1 blanket spent nuclear fuel. While EBR-II spent nuclear fuel is undergoing electrometallurgical treatment and the Fermi-1 blanket spent nuclear fuel remains in storage, DOE has approximately four years in which to evaluate the operating experience of electrometallurgical treatment technology and further evaluate other alternatives for the Fermi-1 blanket spent nuclear fuel. After these data are evaluated, DOE will decide whether to treat the Fermi-1 blanket spent nuclear fuel using electrometallurgical treatment or to use another treatment method and/or disposal technique.

For several years, DOE has been actively developing electrometallurgical treatment technology specifically for the management of sodium-bonded spent nuclear fuel. Having completed a successful demonstration of electrometallurgical treatment, DOE believes that this technology has the highest probability of meeting the objective of reducing the uncertainties associated with qualifying the sodium-bonded spent nuclear fuel for disposal in a geologic repository.

Electrometallurgical technology will convert the reactive fuel into ceramic and metallic waste forms, both of which are more stable than untreated sodium-bonded spent nuclear fuel. In addition, uranium would be separated from the spent nuclear fuel, blended with depleted uranium if needed to reduce the enrichment levels, and cast into ingots to be stored until a disposition decision is made through a separate NEPA review. Most of the plutonium will be disposed of in the ceramic waste form, with the remaining small fraction disposed of in the metallic waste form. Currently, the only waste form that has been tested and analyzed extensively under geologic repository conditions and may be accepted for repository disposal is borosilicate glass. Tests have shown that the ceramic and metallic waste forms from electrometallurgical treatment may perform as well as the standard borosilicate glass waste form. The ceramic and metallic waste forms would require less storage volume than untreated spent nuclear fuel.

IX. Mitigation

The strictly controlled conduct of operations associated with DOE's spent nuclear fuel management activities are integral to the selected alternative. DOE has directives and regulations for safe conduct of spent nuclear fuel treatment and management operations. DOE has adopted stringent controls for minimizing occupational and public radiation exposure. The policy is to reduce radiation exposures to as low as reasonably achievable. Singly and collectively,

these measures avoid, reduce, or eliminate any potentially adverse environmental impacts from spent nuclear fuel treatment and management. DOE has not identified a need for additional mitigation measures.

Issued in Washington, D.C., this 11 day of September 2000.

A handwritten signature in black ink, appearing to read 'W. Magwood, IV', with a large, stylized flourish at the end.

William D. Magwood, IV, Director
Office of Nuclear Energy, Science
and Technology